

**The Use of Smart Video Surveillance  
To Provide Enhanced Perimeter Security  
At Key West International Airport**

---

**2.5. Relation of Proposed Work to Other Work in Progress and Long Term Goals**

ObjectVideo™ was founded in 1998 by a team of noted computer vision research scientists from DARPA and has had, since its foundation, a corporate mission encompassing the two following objectives:

- To undertake research aimed at advancing the state-of-the-art in the field of computer vision
- To pursue business practices aimed at accomplishing the successful, timely and efficient transfer of advances achieved in the course of that research from the laboratory to the video surveillance and video security systems marketplace.

In the release of the ObjectVideo™ VEW product, and its subsequent success in the marketplace, the company has demonstrated its ability to successfully meet both those objectives. ObjectVideo™ continues to pursue a policy of aggressively moving technologies from R&D into features and upgrades to the existing product, and new software offerings. Participation in programs such as the pilot project proposed here for KWI are essential both as a motivator and a testbed for technology in the process of commercialization. Technology developed or fine-tuned under this award is designed to be integrated into either current or future versions of ObjectVideo™ products and services.

KWI sees a vital connection between work proposed for this pilot project and advanced video surveillance capabilities resulting from this pilot that will then be available for proliferation to airports throughout the US, thus enabling a general enhancement in airport security throughout the country.

**2.6. Project Reporting**

An established set of project management procedures which include the generation of a standard set of reports for all projects will be followed for this pilot project. The reports to be produced under this effort will include the following:

- Monthly Project Status Report – providing information on progress made during the reporting month, including progress against project milestones and discussion of any issues, problems, etc encountered during the month
- Monthly Project Financial Report – providing information on money expended on the project during the previous month, and on funds remaining.
- Final Project Summary Report – A Final Project Summary Report will be delivered following the conclusion of the project. This report will provide information on work done, accomplishments and results of the project.

In addition, if circumstances require, ad hoc reports may be generated regarding the specific circumstances or situations. All reports will be provided by the KWI Principal Investigator or KWI Project Manager to the TSA Program Manager, or to an appropriate point of contact designated by the TSA Program Manager.

**The Use of Smart Video Surveillance  
To Provide Enhanced Perimeter Security  
At Key West International Airport**

---

**3. Principal Investigator**

The Principal Investigator for this effort will be Peter Horton.

#### 4. Bibliography

1. G. Di Battista, P. Eades, R. Tamassia and I.G. Tollis, "Graph Drawing: Algorithms for the Visualization of Graphs," Prentice-Hall, 1999.
2. A. Del Bimbo, E. Vicario, D. Zingoni, "A Spatial Logic for Symbolic Description of Image Contents", *Journal of Visual Languages and Computing*, vol. 5, pp. 267-286, 1994.
3. A. F. Bobick and J. W. Davis. "An Appearance-Based Representation Of Action," *ICPR 13*, August 1996
4. E. Boulton, R. Micheals, X. Gao, P. Lewis, C. Power, W. Yin and A. Erkan, "Frame-Rate Omnidirectional Surveillance and Tracking of Camouflaged and Occluded Targets," *Proc. Workshop on Visual Surveillance*, Fort Collins, CO, June 1999.
5. M. Brand, N. Oliver, and A. Pentland. "Coupled Hidden Markov Models For Complex Action Recognition," *CVPR*, 1997.
6. M. Brand and V. Kettner, "Discovery and Segmentation of Activities in Video," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol. 22, no. 8, August 2000.
7. C. Bregler. "Learning and Recognizing Human Dynamics in Video Sequences," *CVPR*, pp. 568-574, 1997.
8. C. Bregler. "Tracking People With Twists And Exponential Maps," *CVPR*, 1998.
9. R. Collins, A. Lipton, T. Kanade, H. Fujiyoshi, D. Duggins, Y. Tsin, D. Tolliver, N. Enomoto, O. Hasegawa, P. Burt, A. Wixson, "A System for Video Surveillance and Monitoring," *CMU Technical Report CMU-RI-TR-00-12*, 2000.
10. D. Comaniciu, V. Ramesh, and P. Meer, "Real-Time Tracking of Non-Rigid Objects using Mean Shift," *CVPR*, pp. II-142-149, 2000.
11. Davis, J. and Bobick, A. "The Representation And Recognition of Action Using Temporal Templates," *CVPR*, pp.928-934. 1997.
12. S. Davies, and A. Moore, "Mix-nets: Factored mixtures of Gaussians in Bayesian networks with mixed continuous and discrete variables", *Sixteenth Conference on Uncertainty in Artificial Intelligence*, 1996.
13. A. Dempster, N. Laird and D. Rubin, "Maximum Likelihood from Incomplete Data via the EM Algorithm," *Journal of the Royal Statistical Society*, 39 (Series B):1-38, 1977.
14. P. Duygulu, N. de Freitas, K. Barnard and D.A. Forsyth, "Object Recognition as Machine Translation," *ECCV*, 2002
15. A. Elgammal, D. Harwood and L. Davis, "Non-parametric Model for Background Subtraction," *Proc. IEEE Frame Rate Workshop*, 1999.
16. Makris, D.[Dimitrios], Ellis, T.[Tim], "Path detection in video surveillance", *IVC(20)*, No. 12, October 2002, pp. 895-903.
17. N. Friedman and S. Russell, "Image Segmentation in Video Sequences: A Probabilistic Approach," *Uncertainty in Artificial Intelligence*, 1997.
18. Y. Gong and X. Liu, "Generating Optimal Video Summaries," *Int'l Conf. Multimedia and Expo*, 2000.
19. E. Grimson, C. Sauffer, R. Romano and L. Lee, "Using Adaptive tracking to Classify and Monitor Activities in a Site," *Proc. Computer Vision and Pattern Recognition Conf.*, pp. 22-29, 1998.
20. N.C. Haering and N. Da Vitoria Lobo, "Visual Event Detection", *Kluwer Academic Press*, 1997
21. K.M. Hall, "An r-dimensional Quadratic Placement Algorithm," *Management Science*, 17:212-229, 1970.
22. I. Haritaoglu, D. Harwood and L. Davis, "W<sup>4</sup>: Real-Time Surveillance of People and Their Activities," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol. 22, no. 8, August 2000.

The Use of Smart Video Surveillance  
To Provide Enhanced Perimeter Security  
At Key West International Airport

---

23. W.H. Highleyman. "Linear Decision Functions, with Applications to Pattern Recognition," *Proc. IRE*, vol 50, pp. 1501-1514, 1962.
24. S. Hongeng and R. Nevatia. "Multi-Agent Event Recognition," *ICCV*, 2001.
25. M. Isard and A. Blake. "CONDENSATION – conditional density propagation for visual tracking," *IJCV*, vol. 29, 1, pp. 5-28, 1998.
26. H. Ismai, D. Harwood and L. Davis, "W4: Who? When? Where? What? A Real Time System for Detecting and Tracking People," 3rd Int'l Conf Automatic Face and Gesture Recognition, 1998.
27. Y. Ivanov and A. Bobick, "Recognition of visual activities and interactions by stochastic parsing", *IEEE Transactions of Pattern Analysis and Machine Intelligence*, Vol 22(8), August 2000, pp.852-872.
28. N. Johnson and D.C. Hogg, *Learning the Distribution of Object Trajectories for Event Recognition*, Image and Vision Computing, 1995.
29. M. Kaufmann and D. Wagner, "Drawing Graphs: Methods and Models," LNCS 2025, Springer Verlag, 2001.
30. V. Kettner and R. Zabih, "Bayesian Multi-Camera Surveillance." *CVPR*, pp. II-253-259, 1999.
31. B. Li, R. Chellappa, Q. Zheng, and S.Z. Der, "Model-based Temporal Object Verification Using Video." *Image Processing* 10(6): 897-908, 2001.
32. G. Medioni, R. Nevatia and I. Cohen. "Event Detection and Analysis from Video Streams," *DARPA98*, pp. 63-72, 1998.
33. D.J. Moore and I.A. Essa. "Recognizing Multitasked Activities using Stochastic Context-Free Grammar." *Proc. of Wkshp. on Models versus Exemplars in Computer Vision*, *CVPR*, 2001.
34. D.J. Moore, I.A. Essa, and M.H. Hayes III. "Exploiting Human Actions And Object Context For Recognition Tasks." *ICCV*, vol. 1, pages 80-86, 1999.
35. M.R. Naphade and T.S. Huang, "A Probabilistic Framework for Semantic Indexing and Retrieval in Video." *IEEE Int'l Conf Multimedia and Expo*, 2000.
36. S.K. Nayar, R. Swaminathan, and J.M. Gluckman, "Combined Wide Angle and Narrow Angle Imaging System and Method for Surveillance and Monitoring." *US Patent # 6,215,519*, 2001.
37. N. Oliver, B. Rosario, and A. Pentland. "Graphical models for recognizing human interactions," *Proc. NIPS*, November 1998.
38. Hanna Pasula, Stuart Russell, Michael Ostland, and Ya'acov Ritov, "Tracking many objects with many sensors." In *Proc. IJCAI-99*, Stockholm, 1999.
39. P.J. Phillips, P. Grother, S. Sarkar, I. Robledo, and K. Bowyer, "Baseline Results for the Challenge Problem of Human ID Using Gait Analysis." 5<sup>th</sup> *IEEE Int'l Conf. on Automatic Face and Gesture Recognition*, 2002.
40. D.E. Rumelhart, G.E. Hinton, and R.J. Williams. "Learning Internal Representations by Back-Propagating Errors," *Nature*, vol. 323, number 99, pp. 533-536, 1986.
41. J. Shi and J. Malik. "Normalized Cuts and Image Segmentation," *CVPR*, pages 731--7, June 1997.
42. C. Stauffer and E. Grimson, "Learning Patterns of Activity Using Real-Time Tracking," *PAMI*, 22(8):747-757, 2000.
43. M. Trajkovic. "Intruder Tracking with a Pan-Tilt-Zoom Camera." *ACCV*, 2002.
44. N. Vaswani, A.R. Chowdhury, and R. Chellappa, "Activity Recognition Using the Dynamics of the Configuration of Interacting Objects." *CVPR*, 2003.
45. L.E. Wixson, R. Mandelbaum, M.W. Hanson, J. Eledath, D. Mishra, "Method and Apparatus for Fixating a Camera on a Target Using Image Alignment." *US Patent 6,396,961*, 2002.
46. C. Wren, A. Azarbayejani, T. Darrell, and A. Pentland. "Pfinder: Real-Time Tracking Of The Human Body," *Photonics East, SPIE*, vol. 2615, 1995.

**The Use of Smart Video Surveillance  
To Provide Enhanced Perimeter Security  
At Key West International Airport**

---

47. K. Woods, D. Cook, L. Hall, L. Stark, "Learning Membership Functions in a Function-Based Object Recognition System", Journal of Artificial Intelligence Research 3, pp187-222, 1995.
48. Z. Zhang, "A Flexible New Technique for Camera Calibration," PAMI 22(11): pp. 1330-1344, August 2000.
49. Q. Zhou and J.K. Aggarwal, "Tracking and Classifying Moving Objects from Video," Proc. 2<sup>nd</sup> IEEE Int. Workshop on PETS, Kauai, HI, December 2001.

**The Use of Smart Video Surveillance  
To Provide Enhanced Perimeter Security  
At Key West International Airport**

---

**5. Appendices**

**5.1. Facilities and Equipment**

ObjectVideo's headquarters office in Reston, Virginia has facilities with a wide range of video processing and storage equipment as well as state-of-the-art software development facilities for developing, testing, integrating, and hardening computer vision algorithms. Development will be done primarily in C++ and C# within a Microsoft environment. Analysis and support tools include a wide range of in-house and commercial packages for analyzing video content and rapidly testing algorithm components. We have a wide variety of test data, including 360° RGB and IR camera video and the equipment to digitize, store, and convert video from almost any commonly used format, such as digital-beta, VHS, MPEG-2, MPEG-4, AVI and many others. Our secure video network and storage system provides several terabytes of on-line digital video storage. We have digital video capable projection systems and meeting rooms for demonstrating our results as well as having the video servers and Internet access required to host streaming video over the Internet as well as private virtual networks.

**The Use of Smart Video Surveillance  
To Provide Enhanced Perimeter Security  
At Key West International Airport**

---

**5.2. Summary Proposal Budget Form**

